

# ◆◆◆ 1. Introduction

$$C = 299\,792\,458 \text{ ms}^{-1}$$

$$\hbar = 1,054\,571\,596(82) \times 10^{-34} \text{ Js}$$

## gravitational constant

$$G_N = 6.673(10) \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ S}^{-2}$$

## Is the gravitational constant fundamental?

### 1. Yes

Then why is

$$m_z = 91.1882 \pm 0.0022 \text{ GeV} / C^2 \quad \text{So small}$$

compared to

$$m_p = \sqrt{\hbar C / G_N} = 1.2210(9) \times 10^{19} \text{ GeV} / C^2 \quad ?$$

### 2. No

What is the fundamental constant and what is the physical mechanism to explain the value of

$$\sqrt{\hbar C / G_N} \quad ?$$

# hierarchy models

	1A	1B	2
	conventional	brane world with warp factor	brane world with tension $\sim$ TeV
hierarchy mechanism	$M_w \sim \frac{M_{inv}^2}{M_{pl}}$	$M_w \propto e^{-kr_c \phi } M_{pl}$	$M_{pl}^2 = M_{pl(4+n)}^{2+n} R^n$
possible string model	heterotic $E_8 \times E_8$	M-theory (?)	Type I (?)
signals	light Higgs superparticles	Dirac neutrino (?)	gravity emission Regge excitation
small .	0	?	?
dark matter	neutralino gravitino	D-brane (?)	D-brane (?)
⋮	⋮	⋮	⋮

## Some comments

(1)  $\lambda = (10^{-4} \text{eV})^4$

**Can we get a D-brane solution consistent with this value of  $\lambda$  ?**

(2) Neutrino mass  $m^2 \cong 10^{-4} \text{eV}^2$

$$\frac{M_z}{m_\nu} \sim 10^{14}$$

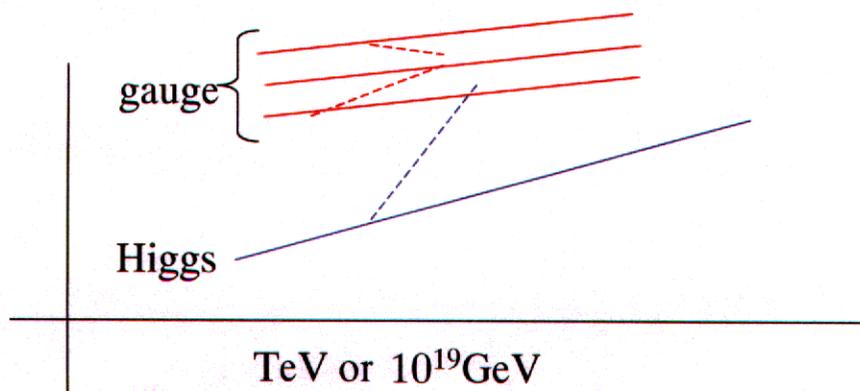
**What is the origin of this number?**

(a)  $m_l \sim \frac{m_w^2}{m_R} \quad ?$

(b) *Kaluza - Klein ground state* ?

(c) *goldstino* ?

**(3) Can Higgs be unified with Yang-Mills ?**



 **Is it possible to study these issues by accelerator?**

**What is the energy required?**

**What kind of machine?**

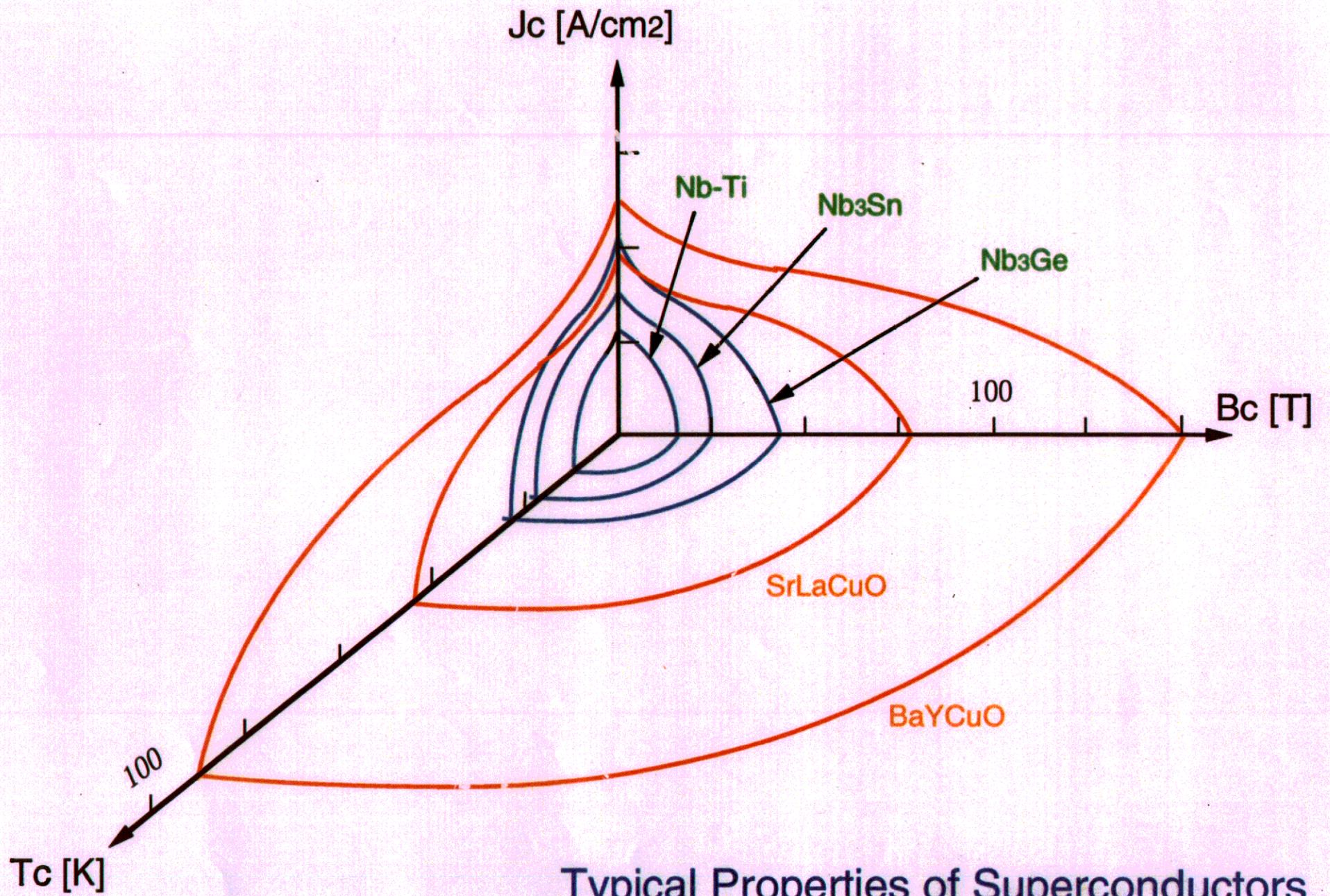
We may be able to answer these questions by constructing  
LHC, (14TeV)  
Linear Collider , (0.5TeV)  
and/or Neutrino Factory,  
as precursor machines.

**If the energy required is**

**PP >100TeV**

**$e^+e^-$  or  $\mu^+\mu^-$  >10TeV,**

**Is it technically feasible?**



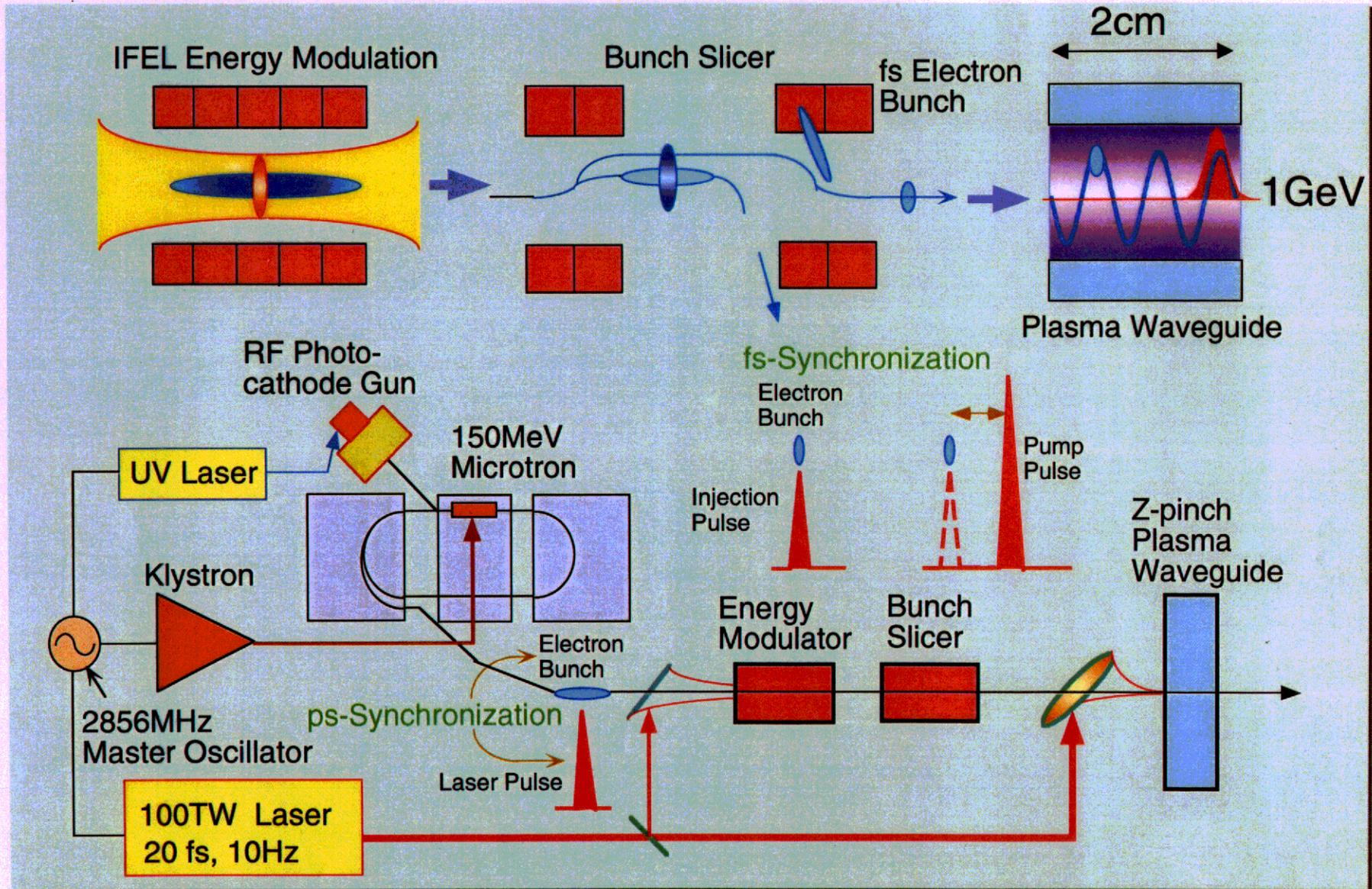
Typical Properties of Superconductors

# *Muon Collider*

## *Technical Problems*

- Accelerator Issues
- High Detector Background
- Radiation Shielding

# GeV Laser Accelerator Developments at JAERI-APR



## **LHC, sub TeV, Neutrino factory**

as precursors

- Higgs study
- Supersymmetry
- neutrino mass and mixing

and

- determination of the energy of VLHC, multi TeV LC or muon collider.

# Energy determination

## 1. Snowmass syndrome

LHC  $\simeq$  1.5 TeV LC



The energy was not determined on the physics basis

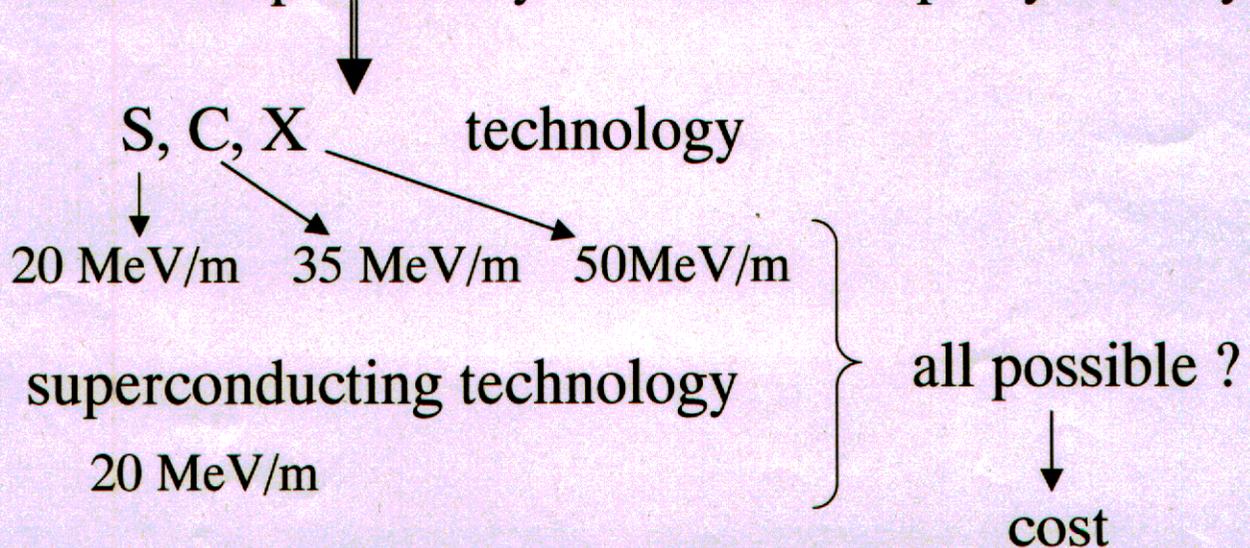
## 2. physics

⊙ low mass Higgs :  $m \lesssim 200\text{GeV}$   
top physics

minimum energy  $\simeq 360\text{ GeV C.M.}$

→ 500 GeV is more or less safe

⊙ “ Complimentary ” to LHC in supersymmetry

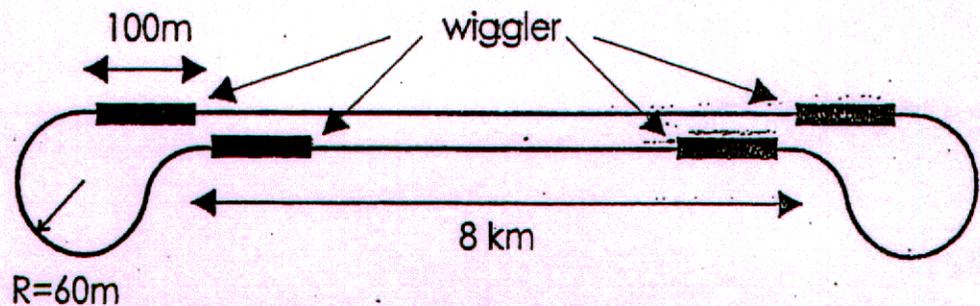


## Comparison of LC projects

	C	X	Tesla
W	2856x2 ~6GHz	2856x4 ~11GHz	1.3GHz
V <sup>2</sup> /P		$\sqrt{\omega}$	$\omega / (A \omega^2 + B)$
$\Delta E (\sigma \Delta E \approx \varepsilon_L)$	large		small
pulse length	(high $\sim \mu s$ peak power)		$10^3 \mu s$
bunches/pulse	$10^2$		$10^3$
bunch spacing	$\sim ns$		$10^2 ns$
bunch length	$< 10^2 \mu m$		$> 10^2 \mu m$
$\varepsilon_{x,y}$	$10, 10^{-2} (\times 10^{-6} mrad)$		$\leq (10, 10^{-2}) \times 10^{-6} mrad$
accelerating field	50MV/m		25MV/m
emittance growth (wake power)	$\omega^3$ large		$\omega^3$ small
cost construction			higher(?)
cost operation	beam power		beam helium

### damping systems

©Tesla



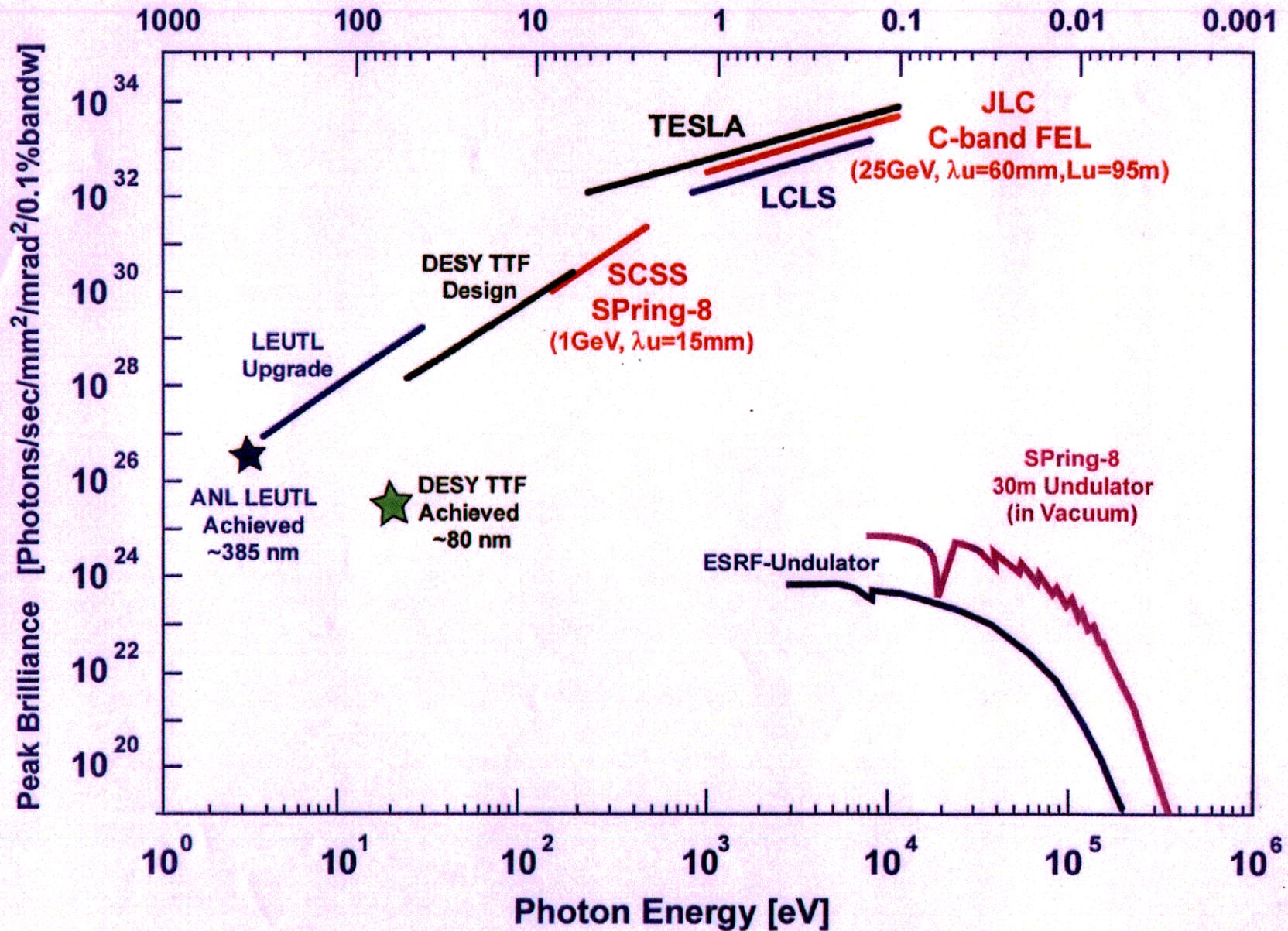
General layout of the "dogbone"-shaped damping ring

©C or X

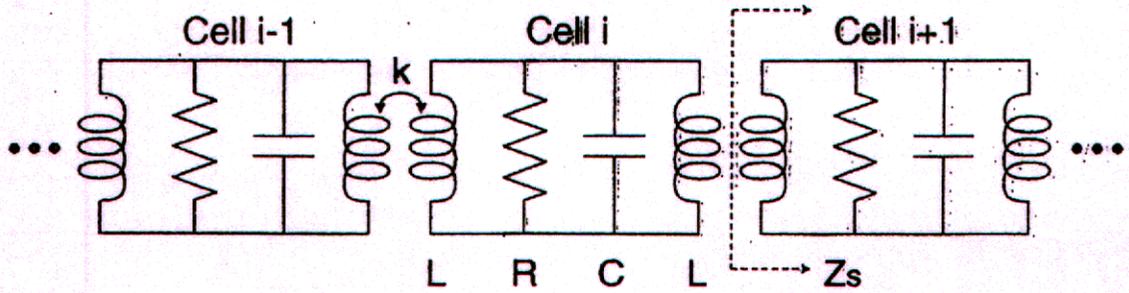
2GeV ring

# Spectral Peak Brilliance of X-ray Free Electron Lasers

Wavelength [nm]



## Structure Impedance



### Structure Parameters

$$f_0 \quad \phi/\text{Cell} \quad R_s \quad Q \quad v_g = \text{Group Velocity} / c$$

### Circuit Parameters

$$k \approx \frac{2 v_g}{\phi \sin(\phi) + 2 v_g \cos(\phi)} \quad \text{and} \quad R_s = R$$

$$L \text{ and } C \text{ from } \sqrt{\frac{2}{LC}} \approx \frac{2\pi f_0}{1 - k/2 \cos(\phi)} \quad \text{and} \quad \sqrt{\frac{L}{2C}} = \frac{R}{Q}$$

### Effective Impedance

$$\therefore Z_s \approx 2 \frac{R/Q}{k \sin(\phi)} \approx \frac{R/Q}{v_g} \frac{\phi \sin(\phi) + 2 v_g \cos(\phi)}{\sin(\phi)}$$

### Power Absorbed in an Arc

$$\text{Power}_{\text{abs}} \approx 4 \frac{R_{\text{arc}}}{Z_s} \text{Power}_{\text{inc}} \approx \frac{R_{\text{arc}}}{(R/Q)^2} \frac{v_g^2}{\omega/c} \frac{4 \sin(\phi) \text{ Gradient}^2}{\phi \sin(\phi) + 2 v_g \cos(\phi)}$$

# Neutrino factory

It is a good thing to continue R/D but may not be appropriate to seriously consider its construction soon.

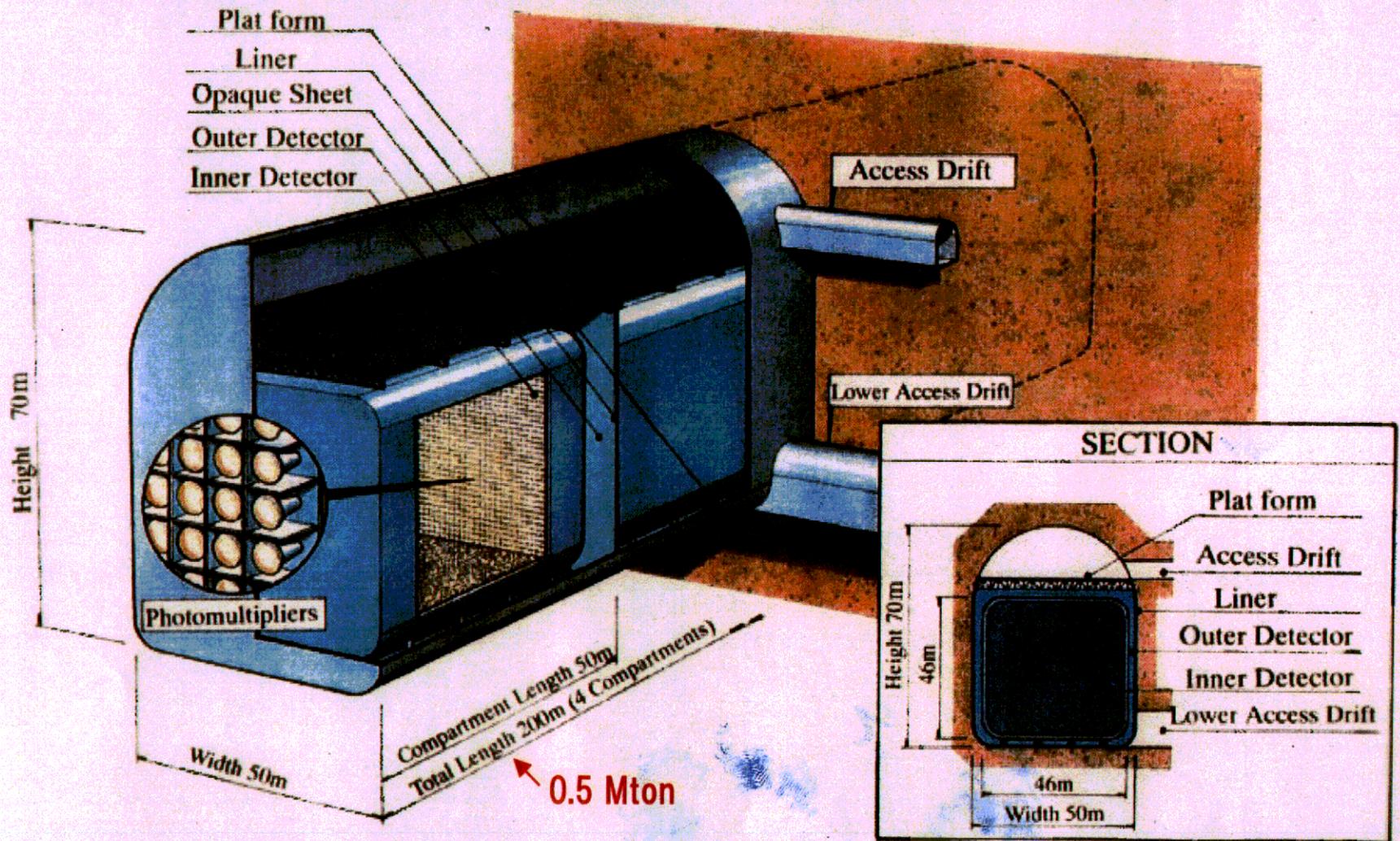
① Megaton detector for proton decay and  $\chi$  in lepton sector

②  $e^+e^-$  vs  $\mu^+\mu^-$



sub TeV LC

# Possible Design of Hyper-Kamiokande



1 Mton: Total Length 400m (8 Compartments)

## Conclusion

**We may need in the first quarter of  
21 century**

- (1) VLHC and multitev lepton collider to understand the hierarchy problem.
- (2) LHC, subtev LC and Neutrino factory can be regarded precursors
- (3) subtev LC is very important.  
Neutrino factory may be seriously considered only when we are convinced the nuon collider is the choice as a multi-tev machine.
- (4) Non-accelerator physics is as important as the accelerator dependent physics.